
APPENDIX A.6 BIOSCREEN EXAMPLES

Example 1: SWMU 66, Keesler AFB, Mississippi

- Input Data
- Fig. 1 Source Map
- BIOSCREEN Modeling Summary
- Fig. 2 BIOSCREEN Input Data
- Fig. 3 BIOSCREEN Centerline Output
- Fig. 4 BIOSCREEN Array Output

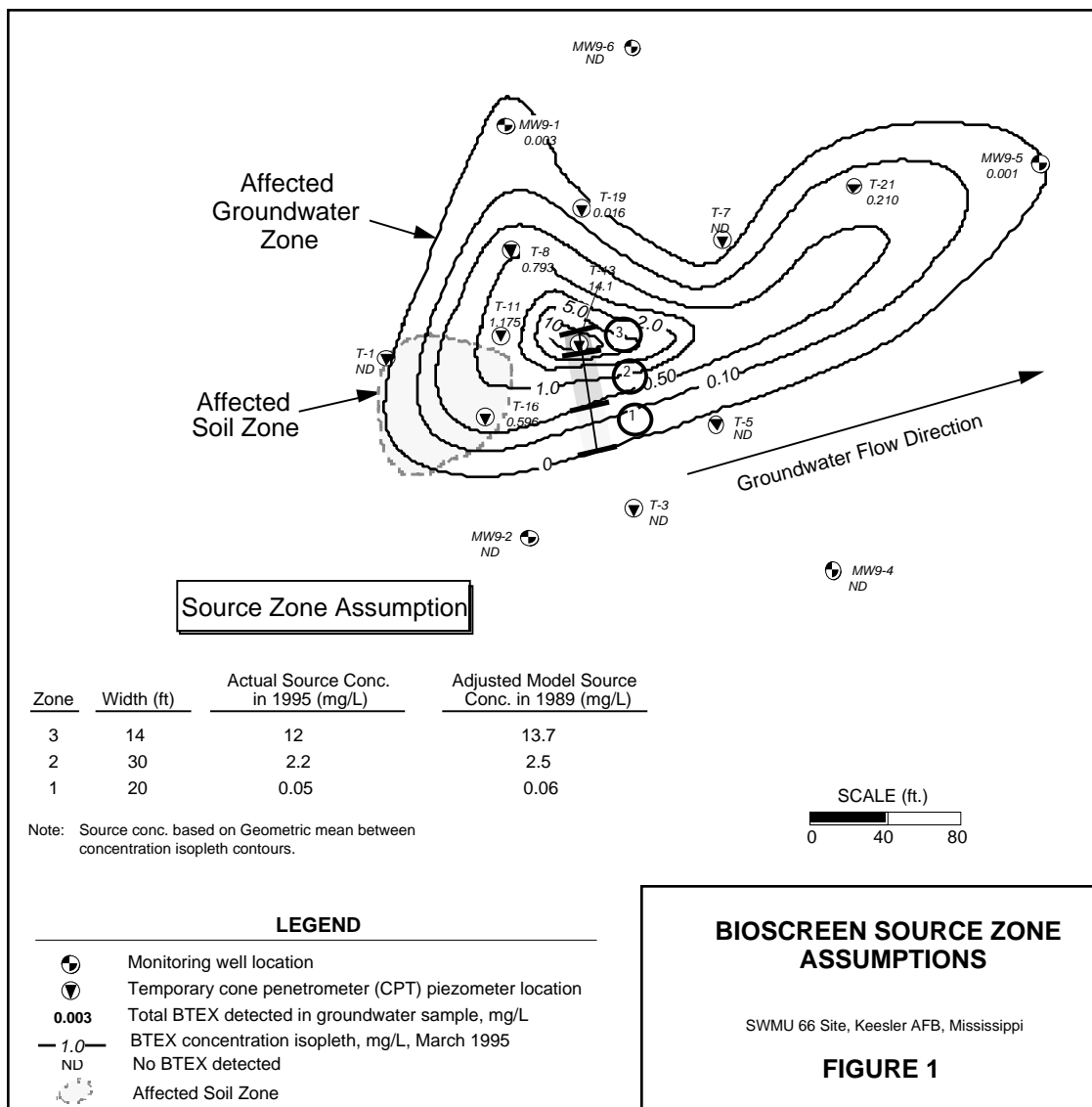
Example 2: UST Site 870, Hill AFB, Utah

- Input Data
- Fig. 5 Source Map
- BIOSCREEN Modeling Summary
- Fig. 6 BIOSCREEN Input Data
- Fig. 7 BIOSCREEN Centerline Output
- Fig. 8 BIOSCREEN Array Output

BIOSCREEN EXAMPLE 1

Keesler Air Force Base, SWMU 66, Mississippi

DATA TYPE	Parameter	Value	Source of Data																		
Hydrogeology	<ul style="list-style-type: none">Hydraulic Conductivity:Hydraulic Gradient:Porosity:	1.1 x 10 ⁻² (cm/sec) 0.003 (ft/ft) 0.3	<ul style="list-style-type: none">Slug-tests resultsStatic water level measurementsEstimated																		
Dispersion	Original: <ul style="list-style-type: none">Longitudinal Dispersivity:Transverse Dispersivity:Vertical Dispersivity: After Calibration: <ul style="list-style-type: none">Longitudinal Dispersivity:Transverse Dispersivity:Vertical Dispersivity:	13.3 (ft) 1.3 (ft) 0 (ft) 32.5 (ft) 3.25 (ft) 0 (ft)	<ul style="list-style-type: none">Based on estimated plume length of 280 ft and Xu/Eckstein relationshipBased on calibration to plume length (Note this is well within the observed range for long. dispersivity; see Fig. A.1 in Appendix A.3. Remember to convert from feet to meters before using the chart).																		
Adsorption	<ul style="list-style-type: none">Retardation Factor: Soil Bulk Density ρ_b:foc:Koc:	1.0 1.7 (kg/L) 0.0057% B: 38 T: 135 E: 95 X: 240	<ul style="list-style-type: none">Calculated from $R = 1 + Koc \times foc \times \rho_b / n$EstimatedLab analysisLiterature - use Koc = 38																		
Biodegradation	Electron Acceptor: Background Conc. (mg/L): Minimum Conc. (mg/L): Change in Conc. (mg/L): Electron Acceptor: Max. Conc. (mg/L): Avg. Conc. (mg/L):	<table><tr><td><u>O2</u></td><td><u>NO3</u></td><td><u>SO4</u></td></tr><tr><td>2.05</td><td>0.7</td><td>26.2</td></tr><tr><td>- 0.4</td><td>- 0</td><td>- 3.8</td></tr><tr><td><div>1.65</div></td><td><div>0.7</div></td><td><div>22.4</div></td></tr></table> <table><tr><td><u>Fe</u></td><td><u>CH4</u></td></tr><tr><td>36.1</td><td>7.4</td></tr><tr><td><div>16.6</div></td><td><div>6.6</div></td></tr></table> Note: Boxed values are BIOSCREEN input values.	<u>O2</u>	<u>NO3</u>	<u>SO4</u>	2.05	0.7	26.2	- 0.4	- 0	- 3.8	<div>1.65</div>	<div>0.7</div>	<div>22.4</div>	<u>Fe</u>	<u>CH4</u>	36.1	7.4	<div>16.6</div>	<div>6.6</div>	<ul style="list-style-type: none">Based on March 1995 groundwater sampling program conducted by Groundwater Services, Inc.
<u>O2</u>	<u>NO3</u>	<u>SO4</u>																			
2.05	0.7	26.2																			
- 0.4	- 0	- 3.8																			
<div>1.65</div>	<div>0.7</div>	<div>22.4</div>																			
<u>Fe</u>	<u>CH4</u>																				
36.1	7.4																				
<div>16.6</div>	<div>6.6</div>																				
General	<ul style="list-style-type: none">Modeled Area Length:Modeled Area Width:Simulation Time:	320 (ft) 200 (ft) 6 (yrs)	<ul style="list-style-type: none">Based on area of affected groundwater plumeSteady-state flow																		
Source Data	<ul style="list-style-type: none">Source Thickness:Source Concentration:	10 (ft) (See Figure 1)	<ul style="list-style-type: none">Based on geologic logs and lumped BTEX monitoring data																		
Actual Data	Distance From Source (ft): BTEX Conc. (mg/L):	<table><tr><td><u>30</u></td><td><u>60</u></td><td><u>180</u></td><td><u>280</u></td></tr><tr><td>5.0</td><td>1.0</td><td>0.5</td><td>0.001</td></tr></table>	<u>30</u>	<u>60</u>	<u>180</u>	<u>280</u>	5.0	1.0	0.5	0.001	<ul style="list-style-type: none">Based on observed concentrations at site										
<u>30</u>	<u>60</u>	<u>180</u>	<u>280</u>																		
5.0	1.0	0.5	0.001																		
OUTPUT	Centerline Concentration:	See Figure 3																			
	Array Concentration:	See Figure 4																			



BIOSCREEN Modeling Summary, Keesler Air Force Base, SWMU 66, Mississippi:

- BIOSCREEN was used to try to reproduce the movement of the plume from 1989 (the best guess for when the release occurred) to 1995.
- The soluble mass in soil and NAPL was estimated by integrating BTEX soil concentrations contours mapped as part of the site soil delineation program. An estimated 2000 Kg of BTEX was estimated to be present at the site. This value represented a source half-life of 60 years with the instantaneous reaction model (the first value shown in the source half-life box in Figure 2), a relatively long half-life, so the 2000 Kg measured in 1995 was assumed to be representative of 1989 conditions.
- The instantaneous reaction model was used as the primary model to try to reproduce the plume length (~ 280 ft).
- Because a decaying source was used, the source concentration on the input screen (representing concentrations 6 yrs ago) were adjusted so the source concentration on the centerline output screen (representing concentrations now) were equal to 12 mg/L. Because the source decay term is different for the first order decay and instantaneous reaction models, this simulation focused on matching the instantaneous reaction model. The final result was a source concentration of 13.68 mg/L in the center of the source zone (note on the centerline output the source concentration is 12.021 mg/L).
- The initial run of the instantaneous reaction model indicated that the plume was too long. This indicates that there is more mixing of hydrocarbon and electron acceptors at the site than is predicted by the model. Therefore the longitudinal dispersivity was adjusted upwards (more mixing) until BIOSCREEN matched the observed plume length. The final longitudinal dispersivity was 32.5 ft.
- As a check the first-order decay model was used with the BIOSCREEN default value of 2 yrs. This run greatly overestimated the plume length, so the amount of biodegradation was increased by decreasing the solute half-life. A good match of the plume was reached with a solute half-life of 0.15 years.
- As shown in Figure 3, BIOSCREEN matches the observed plume fairly well. The instantaneous model is more accurate near the source while the first order decay model is more accurate near the middle of the plume. Both models reproduce the actual plume length relatively well.
- As shown in Figure 4, the current plume is estimated to contain 7.8 kg of BTEX. BIOSCREEN indicates that the plume under a no-degradation scenario would contain 126.3 kg BTEX. In other words BIOSCREEN indicates that 94% of the BTEX mass that has left the source since 1989 has biodegraded.
- Most of the source mass postulated to be in place in 1989 is still there in 1996 (2000 kg vs. 1837 kg, or 92% left).
- The current plume contains 1.0 ac-ft of contaminated water, with 1.019 acre-ft/yr of water being contaminated as it flows through the source. Because the plume is almost at steady state, 1.019 ac-ft of water become contaminated per year with the same amount being remediated every year due to in-situ biodegradation and other attenuation processes.

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.3

Kessler AFB
SWMU 66
Run Name

1. HYDROGEOLOGY

Seepage Velocity* V_s 113.8 (ft/yr)
or
Hydraulic Conductivity K 1.1E-02 (cm/sec)
Hydraulic Gradient i 0.003 (ft/ft)
Porosity n 0.3 (-)

2. DISPERSION

Longitudinal Dispersivity* α_x 32.5 (ft)
Transverse Dispersivity* α_y 3.3 (ft)
Vertical Dispersivity* α_z 0.0 (ft)
or
Estimated Plume Length L_p 280 (ft)

3. ADSORPTION

Retardation Factor* R 1.0 (-)
or
Soil Bulk Density ρ_b 1.7 (kg/l)
Partition Coefficient K_{oc} 38 (L/kg)
Fraction Organic Carbon f_{oc} 5.70E-05 (-)

4. BIODEGRADATION

1st Order Decay Coeff* λ 4.6E+0 (per yr)
or
Solute Half-Life t_{half} 0.15 (year)
or **Instantaneous Reaction Model**
Delta Oxygen* DO 1.65 (mg/L)
Delta Nitrate* NO_3 0.7 (mg/L)
Observed Ferrous Iron* Fe^{2+} 16.6 (mg/L)
Delta Sulfate* SO_4 22.4 (mg/L)
Observed Methane* CH_4 6.6 (mg/L)

5. GENERAL

Modeled Area Length* 320 (ft) L
Modeled Area Width* 200 (ft) W
Simulation Time* 6 (yr)

6. SOURCE DATA

Source Thickness in Sat. Zone* 10 (ft)
Source Zones:

Width* (ft)	Conc. (mg/L)*
28	0.057
30	2.508
14	13.68
30	2.508
28	0.057

Source Decay (see Help):
Source Half-life* 60 - 400 (yr)
Soluble Mass 2000 (Kg)
In NAPL, Soil

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	12.0	5.0	1.0				5			.001	
Dist. from Source (ft)	0	32	64	96	128	160	192	224	256	288	320

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

Recalculate This Sheet

Paste Example Dataset

Restore Formulas for V_s , Dispersivities, R , λ , other

Data Input Instructions:

115 → 1. Enter value directly...or
or
0.02 → 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model. (Don't enter any data).

Figure 2. BIOSCREEN Input Screen. Keesler Air Force Base, Mississippi.

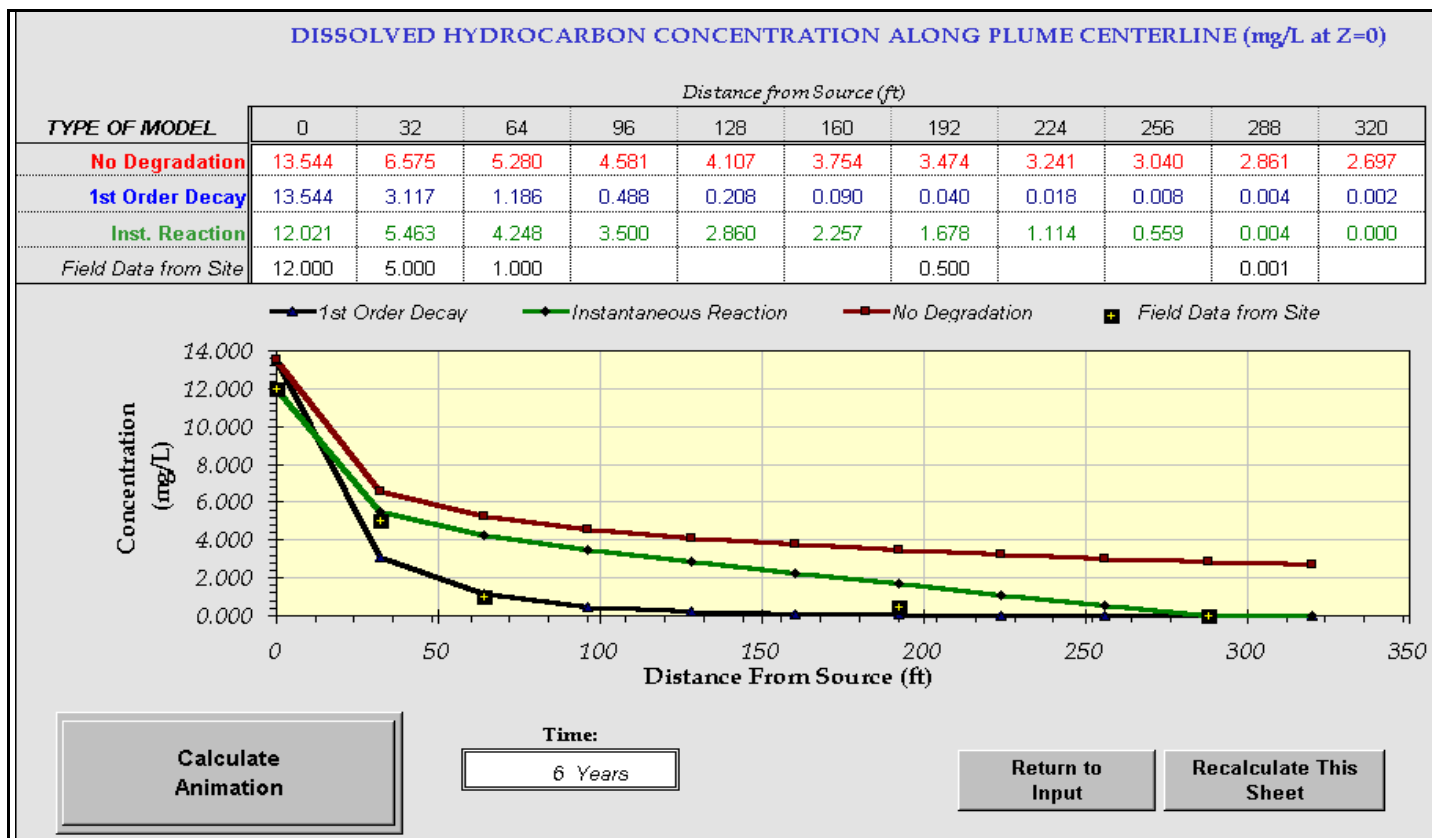


Figure 3. Centerline Output. Keesler Air Force Base, Mississippi.

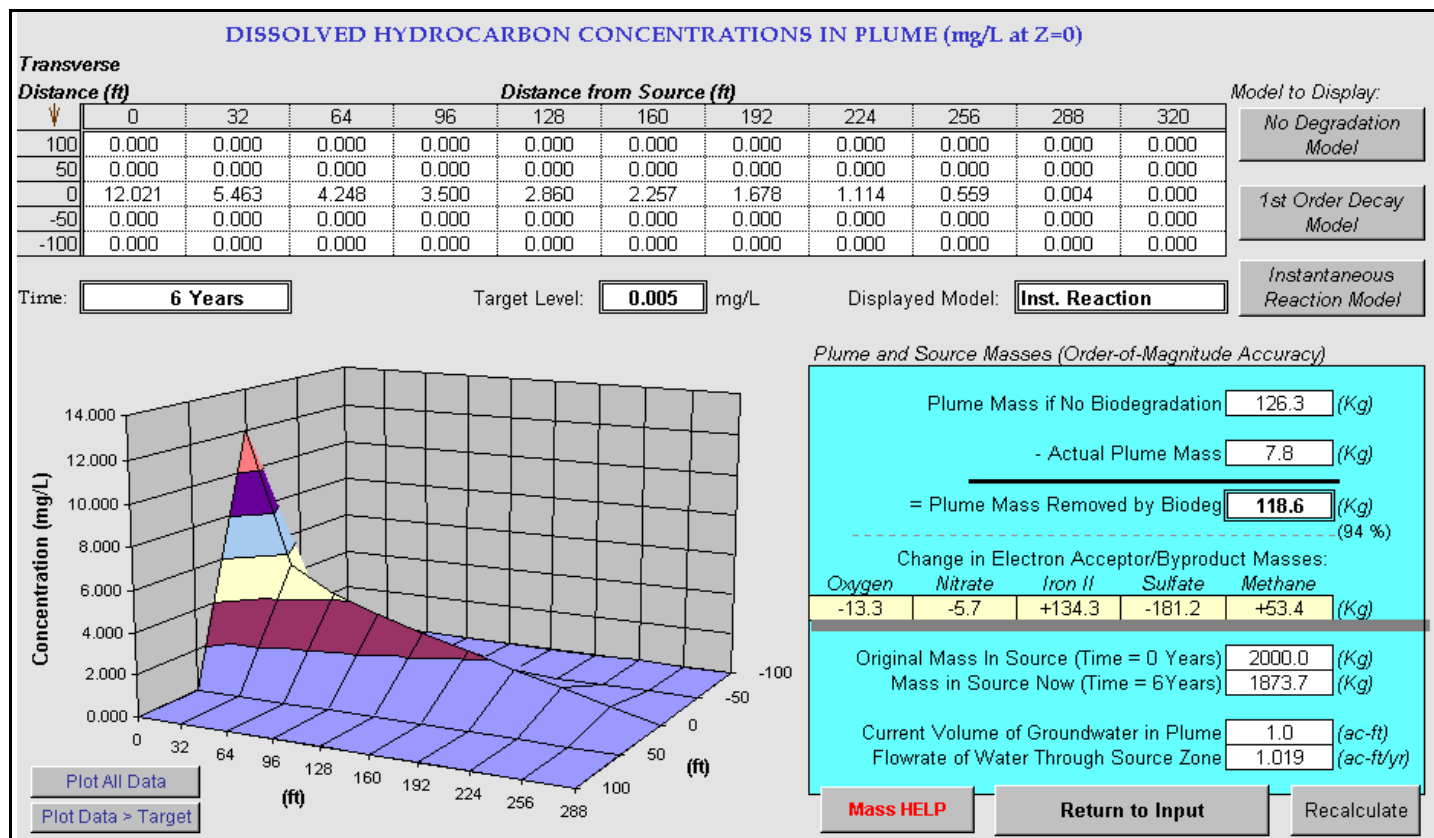
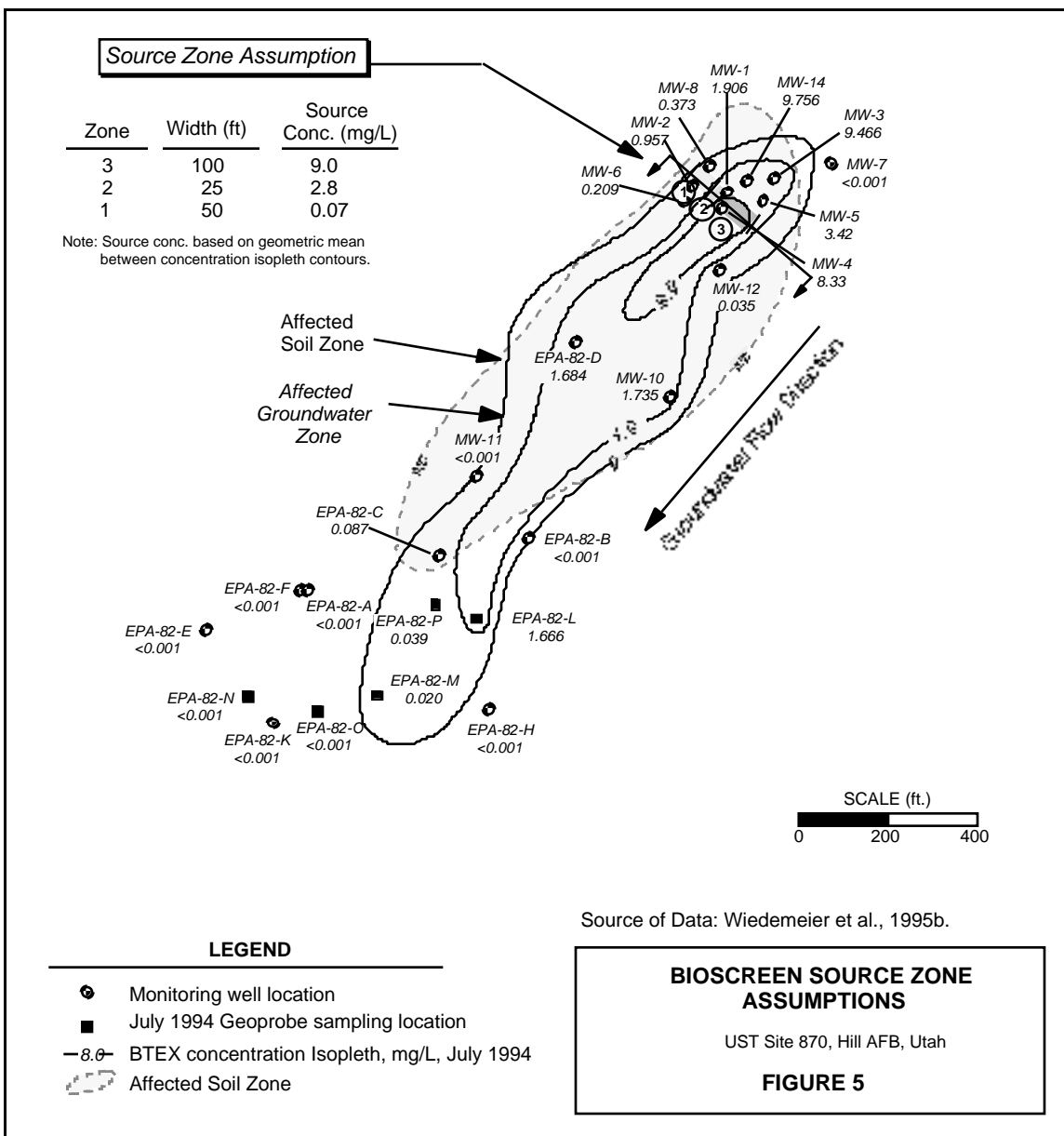


Figure 4. Array Concentration Output. Keesler Air Force Base, Mississippi. EXAMPLE 2

Hill Air Force Base, UST Site 870, Utah

DATA TYPE	Parameter	Value	Source																		
Hydrogeology	<ul style="list-style-type: none">Hydraulic Conductivity:Hydraulic Gradient:Porosity:	8.05 x 10 ⁻³ (cm/sec) 0.048 (ft/ft) 0.25	<ul style="list-style-type: none">Slug-tests resultsStatic water level measurementsEstimated																		
Dispersion	Original <ul style="list-style-type: none">Longitudinal Dispersivity:Transverse Dispersivity:Vertical Dispersivity:	28.5 (ft) 2.85 (ft) 0 (ft)	<ul style="list-style-type: none">Based on estimated plume length of 1450 ft and Xu's dispersivity formulaNote: No calibration was necessary to match the observed plume length.																		
Adsorption	<ul style="list-style-type: none">Retardation Factor: Soil Bulk Density ρ_b:foc:Koc:	1.3 1.7 (kg/L) 0.08% B: 38 T: 135 E: 95 X: 240	<ul style="list-style-type: none">Calculated from $R = 1 + Koc \times foc \times \rho_b / n$EstimatedLab analysisLiterature - use Koc = 38																		
Biodegradation	Electron Acceptor: Background Conc. (mg/L): Minimum Conc. (mg/L): Change in Conc. (mg/L): Electron Acceptor: Max. Conc. (mg/L): Avg. Conc. (mg/L):	<table><tr><td><u>O2</u></td><td><u>NO3</u></td><td><u>SO4</u></td></tr><tr><td>6.0</td><td>17.0</td><td>100</td></tr><tr><td>- 0.22</td><td>- 0</td><td>- 0</td></tr><tr><td><u>5.78</u></td><td><u>17.0</u></td><td><u>100</u></td></tr></table> <table><tr><td><u>Fe</u></td><td><u>CH4</u></td></tr><tr><td>50.5</td><td>2.04</td></tr><tr><td><u>11.3</u></td><td><u>0.414</u></td></tr></table> Note: Boxed values are BIOSCREEN input values.	<u>O2</u>	<u>NO3</u>	<u>SO4</u>	6.0	17.0	100	- 0.22	- 0	- 0	<u>5.78</u>	<u>17.0</u>	<u>100</u>	<u>Fe</u>	<u>CH4</u>	50.5	2.04	<u>11.3</u>	<u>0.414</u>	<ul style="list-style-type: none">Based on July 1994 groundwater sampling program conducted by Parsons Engineering Science, Inc.
<u>O2</u>	<u>NO3</u>	<u>SO4</u>																			
6.0	17.0	100																			
- 0.22	- 0	- 0																			
<u>5.78</u>	<u>17.0</u>	<u>100</u>																			
<u>Fe</u>	<u>CH4</u>																				
50.5	2.04																				
<u>11.3</u>	<u>0.414</u>																				
General	<ul style="list-style-type: none">Modeled Area Length:Modeled Area Width:Simulation Time:	1450 (ft) 320 (ft) 5 (yrs)	<ul style="list-style-type: none">Based on area of affected groundwater plumeSteady-state flow																		
Source Data	<ul style="list-style-type: none">Source Thickness:Source Concentration:	10 (ft) (See Figure 5)	<ul style="list-style-type: none">Based on geologic logs and lumped BTEX monitoring data																		
Actual Data	Distance from Source (ft): BTEX Conc. (mg/L):	<table><tr><td><u>340</u></td><td><u>1080</u></td><td><u>1350</u></td><td><u>1420</u></td></tr><tr><td>8.0</td><td>1.0</td><td>0.02</td><td>0.005</td></tr></table>	<u>340</u>	<u>1080</u>	<u>1350</u>	<u>1420</u>	8.0	1.0	0.02	0.005	<ul style="list-style-type: none">Based on observed concentration contour at site (see Figure 5)										
<u>340</u>	<u>1080</u>	<u>1350</u>	<u>1420</u>																		
8.0	1.0	0.02	0.005																		
OUTPUT	Centerline Concentration:	See Figure 7																			
	Array Concentration:	See Figure 8																			



BIOSCREEN Modeling Summary Hill Air Force Base, UST Site 870, Utah:

- BIOSCREEN was used to try to reproduce the movement of the plume.
- An infinite source was assumed to simplify the modeling scenario. The source was assumed to be in the high concentration zone of the plume area (see Figure 5). Note that the zone of affected soil was quite large; however much of the affected soil zone downgradient of the source was relatively low concentration.

Two modeling approaches could be applied: 1) assuming the source zone is just downgradient of the affected soil area (near well EPA-82-C) and ignoring the area upgradient of the this point, and 2) modeling most of the plume with source near MW-1. Alternative 1 is theoretically more accurate, as BIOSCREEN cannot account for the contributions from any affected soil zone downgradient of the source. At the case of Hill AFB, however, it was assumed that the contributions from this downgradient affected soil were relatively minor and that the main process of interest was the length of the plume from the high-concentration source zone. Therefore Alternative 2 was modeled, with the note that the middle of the actual plume may actually have higher concentrations than would be expected due to the contaminants in the downgradient affected soil zone.

- The instantaneous reaction model was used as the primary model to try to reproduce the plume length (~ 280 ft) as shown in Figure 7.
- The initial run of the instantaneous reaction model reproduced the existing plume without any need for calibration of dispersivity.
- As a check the first-order decay model was used with the BIOSCREEN default value of 2 yrs. This run greatly overestimated the plume length, so the amount of biodegradation was increased by decreasing the solute half-life. A half-life value of 0.1 years was required to match the plume length, although the match in the middle in the plume was much poorer.
- As shown in Figure 7, BIOSCREEN matches the observed plume fairly well. The instantaneous model is more accurate near the source while the first order decay model is more accurate near the middle of the plume. Both models reproduce the actual plume length relatively well.
- As shown in Figure 8, the model was unable to calculate the mass balances. A quick evaluation shows the reason: with a seepage velocity of 1609 ft/yr and a 5 year simulation time, the undegraded plume should be over 8000 ft long. Because the mass balance is based on a comparison of a complete undegraded plume vs. a degraded plume, a model area length of 8000 ft would be required for BIOSCREEN to complete the mass balance calculation. Therefore two runs would be needed to complete the simulation: 1) a run with a modeled length of 1450 feet to calibrate and evaluate the match to existing data, and 2) a run with a modeled length of 8000 ft to do the mass balance. The results of the second run (change of model area length from 1450 ft to 8000 ft) indicate that over 99% of the mass that has left the source has biodegraded by the time groundwater has traveled 1450 ft.

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Hill AFB
UST Site 870
Run Name

Version 1.3

Data Input Instructions:

115 → 1. Enter value directly...or
↑ or 2. Calculate by filling in prev
0.02 cells below. (To restore
formulas, hit button below).

Variable* → Data used directly in model.
20 → Value calculated by model.
(Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity* Vs 1609.1 (ft/yr)
or
Hydraulic Conductivity K 8.1E-03 (cm/sec)
Hydraulic Gradient i 0.048 (ft/ft)
Porosity n 0.25 (-)

2. DISPERSION

Longitudinal Dispersivity* alpha x 28.5 (ft)
Transverse Dispersivity* alpha y 2.9 (ft)
Vertical Dispersivity* alpha z 0.0 (ft)
or
Estimated Plume Length Lp 1450 (ft)

3. ADSORPTION

Retardation Factor* R 1.2 (-)
or
Soil Bulk Density rho 1.7 (kg/l)
Partition Coefficient Koc 38 (L/kg)
FractionOrganicCarbon foc 8.00E-04 (-)

4. BIODEGRADATION

1st Order Decay Coeff* lambda 6.9E+0 (per yr)
or
Solute Half-Life t-half 0.10 (year)
or Instantaneous Reaction Model

Delta Oxygen* DO 5.78 (mg/L)
Delta Nitrate* NO3 17 (mg/L)
Observed Ferrous Iron* Fe2+ 11.3 (mg/L)
Delta Sulfate* SO4 100 (mg/L)
Observed Methane* CH4 0.414 (mg/L)

5. GENERAL

Modeled Area Length* 1450 (ft)
Modeled Area Width* 320 (ft)
Simulation Time* 5 (yr)

6. SOURCE DATA

Source Thickness in Sat.Zone* 10 (ft)
Source Zones:

Width* (ft)	Conc. (mg/L)*
50	0.07
25	2.8
100	9
25	2.8
50	0.07

Source Decay (see Help):
SourceHalfLife* Infinite (yr)
Soluble Mass In NAPL, Soil Infinite (Kg)

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	9.0	8.0					1.0		.02	.005
Dist. from Source (ft)	0	145	290	435	580	725	870	1015	1160	1305

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

Recalculate This Sheet

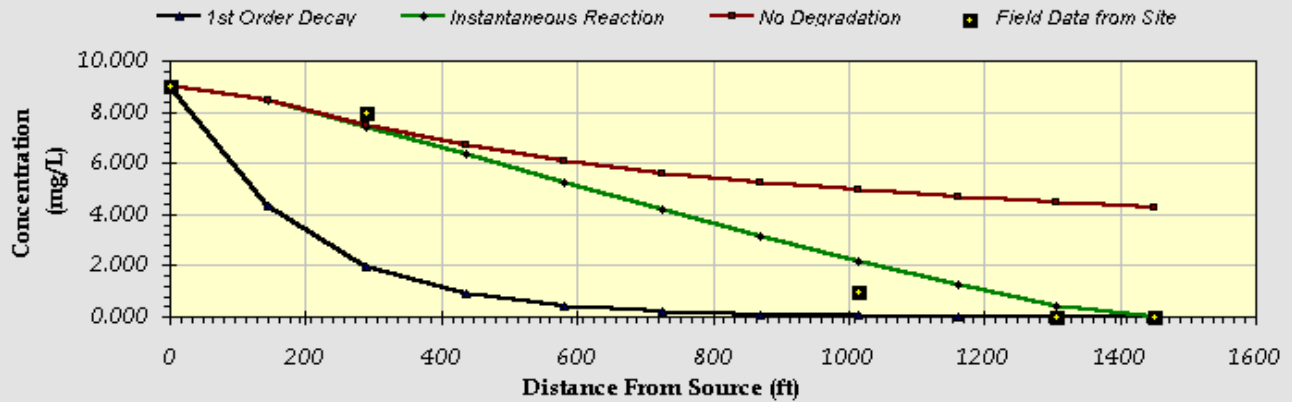
Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Figure 6. BIOSCREEN Input Screen. Hill Air Force Base, Utah.

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft)										
	0	145	290	435	580	725	870	1015	1160	1305	1450
No Degradation	9.000	8.467	7.466	6.684	6.089	5.624	5.250	4.940	4.679	4.455	4.260
1st Order Decay	9.000	4.348	1.969	0.905	0.424	0.201	0.096	0.047	0.023	0.011	0.005
Inst. Reaction	9.000	8.466	7.407	6.350	5.268	4.192	3.152	2.168	1.245	0.385	0.000
Field Data from Site	9.000		8.000					1.000		0.020	0.005



Calculate
Animation

Time:

5 Years

Return to
Input

Recalculate This
Sheet

Figure 7. Centerline Output. Hill Air Force Base, Utah.

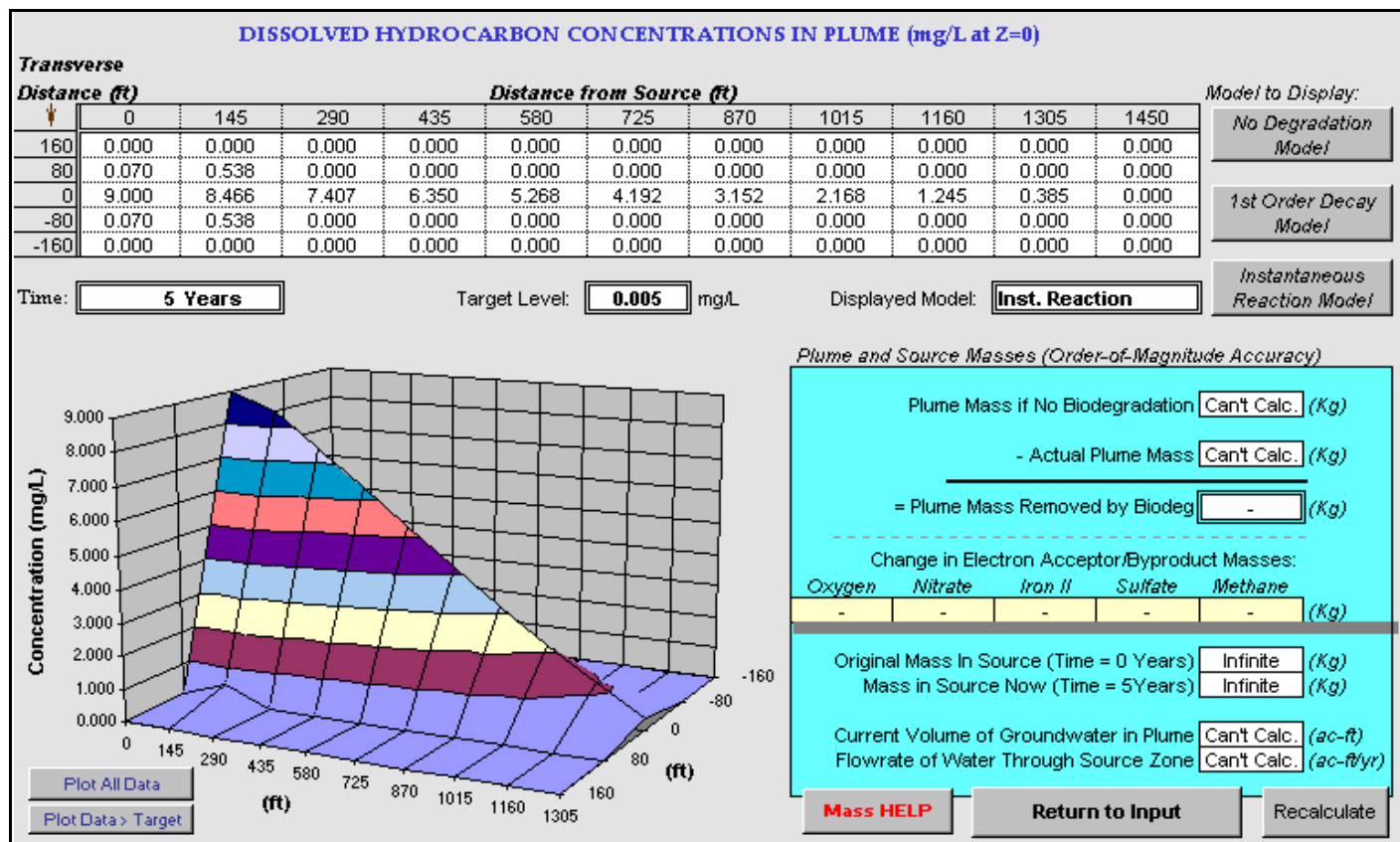


Figure 8. Array Concentration Output. Hill Air Force Base, Utah.